# APPENDIX B: LITERATURE REVIEW OF POTENTIAL ISS MARKET SECTORS

**LITERATURE REVIEW OF POTENTIAL ISS MARKET SECTORS CONTENTS:**



The contents of this appendix are focused on the various commercial sectors that might utilize some aspect of the ISS as a catalyst for other future commercial space activities. The documents listed in this appendix are neither intended to provide market forecasts nor to support a particular political position on the ISS. Rather, they are intended to give the reader a sense of the discussions that have taken place over the period of 1995 to present.

Brief summaries and/or abstracts of the following publications are provided as representative samples of the documentation reviewed and do not represent the entire body of work reviewed during the course of this study.

A number of the research areas that potentially could be conducted on the ISS do not have any documentation that met the criteria of the study parameters. This is not to say that the commercial potential of these research areas is non-existent, only that we were unable to find suitable documentation that focused solely on that particular research subject. Occasionally, publications are provided at the top level of specific topic areas because they may cover several or all of the various disciplines within that particular topic area.

In addition, several of the documents do not adhere strictly to our study guidelines but were noted due to their unique contribution to the overall report. The papers are presented in approximate reverse chronological order, from 1999 to 1995.

# BIOTECHNOLOGY

## BIOTECHNOLOGY CONTENTS:

- Tissue Engineering
- Pharmaceutical
- Agriculture

Description:

Biotechnology is a set of enabling technologies which allows the use of organisms or their cellular, sub-cellular or molecular components, to make products; or to modify plants, animals and microorganisms to carry desired traits.

The ISS R&D facilities provide an environment that could accelerate breakthroughs in biotechnology through research and production in microgravity. This section will be limited to covering the biotechnology disciplines identified in our review that could potentially benefit from research on the ISS, namely tissue engineering, pharmaceuticals and agricultural biotechnology.

## NASA RESEARCH PLAN

*"Biotechnology is the application of engineering and technology to life sciences research. Two primary areas of biotechnology will be researched on ISS: protein crystal growth and cell & tissue culturing. Protein crystal growth is essential in understanding the structure and function of proteins. Growing protein crystals in space allows some to grow larger and with greater perfection than Earth-grown ones. The larger molecular size and greater perfection makes determining their structure with x-ray diffraction much more effective. Once the structure is determined, the protein may be altered and/or synthesized in mass quantities. This process, called rational drug design, may produce more effective medicines while reducing side effects.*

*Growing tissue samples is one of the fundamental goals of biomedical research. Scientists use laboratory containers called bioreactors to culture samples of body tissues. Scientists could use cancer tumors and other tissues that are successfully grown outside the body to test and study treatments, such as chemotherapy, without risking harm to patients. These tissues from bioreactors will also offer important medical insights into how tissues grow and develop in the body. NASA engineers have already created breakthrough technologies for cell culture research on the ground. For example, NASA-developed bioreactors have already produced the first 80-day*

*lung culture, the first normal human intestine culture, and major advances in the quality of cancer tumor cultures. In the long term, tissues cultured outside the body may be used directly for replacing damaged tissues, treating diseases, or eventually replacing organs.*

Shuttle astronaut Dan Bursch explains why growing crystals in space is important to us here on Earth:

*"The National Institute of Health has said that protein crystal growth is the number one research tool that we'll be using in the next century... What happens here on Earth is that gravity actually distorts the shape of the crystal and actually ends up getting imperfections in it. What we can do in space is grow the crystals - most of the time grow them larger and in a more pure form - bring them back, and the larger crystal allows us to get a much better diffraction pattern out of the protein.*

*"The whole goal is to eventually synthesize the protein. There was a protein that I flew on one of my past flights called alpha interferon that's used in the treatment of cancer. The treatment has some bad side effects. If we understand the structure of the protein then we can alter the protein just so slightly and then synthesize it. We can make a whole new family of pharmaceuticals that can be used in the treatment of cancer, but without the bad side effects."*

A Strategy for Research in Space Biology and Medicine in the New Century, Space Studies Board, National Research Council, 1998.

*"The core of the National Aeronautics and Space Administration's (NASA's) life sciences research lies in understanding the effects of the space environment on human physiology and on biology in plants and animals…During the past decade there has been an explosion of new scientific understanding catalyzed by advances in molecular and cell biology and genetics, a substantially increased amount of information from flight experiments, and the approach of new opportunities for long-term space-based research on the International Space Station. A reevaluation of opportunities and priorities for NASA-supported research in the biological and biomedical sciences is therefore desirable."*

Weightlessness and the Human Body, Ronald White, Scientific American, September 1998.

*"The effects of space travel on the body resemble some of the conditions of aging. Studying astronauts' health may improve medical care both in orbit and on the ground..."*

Global Cooperation Enhances Space Flight Research, Steve Bunk, The Scientist, June 8, 1998.

> *"Before the April 17 launch of Neurolab, the 16-day space shuttle Columbia flight during which 26 studies of the nervous system would be conducted, researchers differed in opinion concerning the microneurography experiment. Either a thin needle placed in a nerve just below the knee of an astronaut would show that electrochemical signals were being transmitted normally from brain to blood vessels via the autonomic nervous system, or the nerve activity would be greater in microgravity than on Earth, or it would decrease during space flight and the experiment wouldn't work at all...."*

Space Research May Accelerate Flu-Fighting Drug Development, Charles W Henderson, Tuberculosis & Airborne Disease Weekly, March 29, 1999.

> *"Even with vaccines, 20-40 million people in the United States catch the flu each year, and thousands are at risk of dying from its complications."*

> *"In the future, a new class of prescription drugs called neurominidase inhibitors offers the prospect for decreasing the duration and severity of the illness and may even prevent the development of symptoms in those exposed to the virus. One of these neurominidase inhibitors was developed through ground and space research conducted in partnership by NASA and the Center for Macromolecular Crystallography at the University of Alabama at Birmingham (UAB)..."*

Protein Crystal Growth in Microgravity: Status and Commercial Implications, Karen M. Moore, Marianna M. Long, Lawrence J. DeLucas, Space Technology and Applications International Forum - 1999.

> *"These experiments have successfully demonstrated that the low gravity environment can be used to produce crystals of proteins and other macromolecules that are superior to crystals of the same compounds grown on earth. Improved, extended x-ray diffraction data collected from space-grown crystals has contributed to the solution of the three-dimensional structures of many proteins and has augmented structure-based drug design studies targeting several diseases and degenerative conditions."*

The BioDyn Facility on ISS: Advancing Biomaterial Production in Microgravity for Commercial Applications, Niki Myers, Francis Wessling, Mark Deuser, C.D. Anderson, Marian Lewis, Space Technology and Applications International Forum - 1999.

> *"The primary goals of the BioDyn program are to foster use of the microgravity environment for commercial production of bio-materials from cells, and to develop services and processes for obtaining these materials through space processing."*

Potential Commercial Use of the International Space Station by the Biotechnology/Pharmaceutical/ Biomedical Sector, George Morgenthaler, Louis Stodieck, Space Technology and Applications International Forum - 1999.

> *"The International Space Station (ISS) is the lynch-pin of NASA's future space plans. It emphasizes scientific research by providing a world-class scientific laboratory in which to perform long-term basic science experiments in the space environment of microgravity, radiation, vacuum, vantage-point, etc. It will serve as a test-bed for determining human system response to long-term space flight and for developing the life support equipment necessary for NASA's Human Exploration and Development of Space (HEDS) enterprise. The ISS will also provide facilities (up to 30% of the U.S. module) for testing material agricultural, cellular, human, aquatic and plant/animal systems to reveal phenomena heretofore shrouded by the veil of 1-g. These insights will improve life on Earth and will provide a commercial basis for new products and services."*

State Native's Work Flies, Karen Klinka, The Sunday Oklahoman, November 1, 1998.

> *"Dr. Daniel Carter, 44, created the Protein Crystallization Apparatus for Microgravity, or P-CAM, a high-capacity crystal growth unit housing 378 viral experiments..."*

Making Space on Earth: Researchers Stimulate Microgravity to Study Cells, Viruses, Mark Somerson, The Columbus Dispatch, November 6, 1998.

> *"Armed with NASA funds and high-tech equipment, researchers John Hughes and Jim Long are mimicking zero-gravity conditions to grow cells into three-dimensional tissue - a method that allows scientists to observe life's building blocks in a whole new light..."*

NASA picks 48 Researchers for Biotech Work in Microgravity, Aerospace Daily, December 21, 1998.

> *"NASA has picked 48 researchers to share about $33 million worth of grants for microgravity biotechnology research in such areas as protein crystallization, cell science and new technology development that could lead to new designer drugs, "tissue engineering" and new biosensors..."*

Drug Development NASA Research Helps Map Protein Structures, Tuberculosis & Airborne Disease Weekly, September 28, 1998.

> *"Research sponsored by the National Aeronautics and Space Administration (NASA) Microgravity Research Program at Marshall Space Flight Center, is making significant contributions to scientists' understanding of the molecular structure of living things - a key to the development of new disease-fighting drugs."*

Research drought looms after Neurolab mission; no further flights scheduled for Spacelab program, Andrew Lawler, American Association for the Advancement of Science, April 24, 1998.

> *"Museums in Washington, D.C. and Bremen, Germany, are already preparing to display segments from the first reusable laboratory in space, now orbiting Earth as the Neurolab mission aboard the space shuttle Columbia. Neurolab is the last scheduled flight in the 15-year-old Spacelab program, and its demise threatens to turn the business of conducting lab experiments in space into a museum piece as well: Over the next few years, until the yet-to-be-built international space station is ready for use, opportunities for such research will be few and far between.*
>
> *"It's an absolutely major problem," says Mary Jane Osborn, a biologist at the University of Connecticut, Farmington, who also chairs the National Research Council's space biology panel. "If there are no flights for 5 years, the community is going to evaporate." That worry is shared by Europeans, who spent more than $1 billion to build Spacelab. "It's a very grave danger," says Guenther Seibert, chief of the European Space Agency's microgravity and space station utilization effort. "NASA doesn't have money for more Spacelab missions, and we don't have money for new payloads." NASA insists it can cobble together enough flight opportunities to tide researchers over until the station is ready. In the meantime, a debate rages over whether such expensive flights provide good scientific value for the money.*

*A major stumbling block for conducting experiments in space, however, is money. Crewed missions are notoriously expensive -- about half a billion dollars per shuttle flight. "It's costly as hell," says Simon Ostrach, a materials scientist at Cleveland's Case Western Reserve University who has flown experiments on Spacelab. "I'm not sure any scientist would say it's worth the cost of shuttle flights." Still, he adds, costs are relative. "Physicists, for example, use some pretty expensive facilities, too." Robert Park, a physicist at the American Physical Society, notes that Spacelab-related research is probably the costliest in history. "Some of the science is probably worth doing, but there is a lot of science we don't do because it costs too much."*

NASA Biotech Spinoff Seeks Commercial Operation on Station, Aerospace Daily, November 11, 1997.

*"Cry-X Inc., a biotechnology startup spun off from the NASA-backed Center for Macromolecular Crystallography, is developing business plans and hardware for a commercial protein crystal unit on the International Space Station that would charge pharmaceutical companies "user fees" to create tiny building blocks for drug research in space."*

## TISSUE ENGINEERING

Description:

This area of space research shows particular promise in the treatment of diseases such as aging, degenerative diseases, burns, blood and lymphoid disorders, structural tissue deficits and vital organ failure.

On Earth, in-vitro tissue growth is typically accomplished by seeding organ-specific cells onto biodegradable, three-dimensional, scaffold in a bioreactor that simulates the environment in the body. The cells attach, divide and secrete extra-cellular matrix proteins and growth factors, forming functional tissue. In-vivo tissue growth is typically performed by performing the above in a living host or by injecting growth factors to promote the host's own cell growth. Other current application areas include:

- Cells combined with biomaterials and active substances
- Isolated cells used for implantation
- Biomaterials-based scaffolds for the growth of new tissue
- Tissue engineered small-diameter vascular grafts that could be used as a viable alternative to coronary bypass surgery
- The administration of active substances to affect endogenous tissue
- Connective tissue
- Inter-vertebral discs
- The replacement of aged muscle
- The replacement of aged corneas.

Tissue Engineering in Microgravity: Potentials for Biotechnology within the Applications Promotion Programme of the European Space Agency, Roger A. Binot, ESA, ESTEC.

> *"Experimental data obtained in microgravity conditions aboard spacecraft or during ground microgravity/hypergravity simulation studies indicate a change in cell function related to the gravity level."*

## PHARMACEUTICALS

Description:

Pharmaceuticals research may be broken down into four key focus areas for ISS-related microgravity research. These are pharmaceutical preparations, medicinals and botanicals, biological products and diagnostics.

Structure-based drug design technology, also called rational drug design, a method that relies on protein crystal growth and x-ray crystallography, is becoming an integral part of the drug development process. Analyzing such crystals, using X-ray crystallography, is the best way to understand their structure. From this, scientists can determine how bacteria, viruses and our own bodies work and how best to design drugs to cure disease.

During the course of our research we found no publicly available reports that specifically address the paid commercial utilization of the ISS for research based on the criteria established for this study.

## AGRICULTURE

Description:

Agricultural biotechnology comprises a multitude of research areas that may lead to development of new agricultural processes and plant species as well as new chemicals and other critical materials. When applied to the field of agriculture, the benefits are enhanced production, increased nutritional quality and higher disease resistance of crops and animals.

Microgravity May Enhance Gene Transfer in Plants, SpaceDaily, April 27, 1999.

> *"Transferring desirable genes into crops is a high-tech game of chance, with success rates running about 1 in 1,000. But the odds get a whole lot better, it seems, when you remove gravity from the mix.*
>
> *An industry-sponsored research project aboard the Oct. 29 NASA Space Shuttle suggests that microgravity might enhance genetic engineering of plants. The project, coordinated by UW-Madison's Wisconsin Center for Space Automation and Robotics (WCSAR), tested a unique technology that uses bacteria as a means for gene transfer."*

Zero-Gravity Soybeans Could Be Medicinal, Jenni Laidman, Press Journal, April 18, 1999.

> *"If you think soybeans are good for you now, just wait until space-grown soybeans hit the market.*
>
> *Stephen L. Goldman, the director of the Plant Science Research Center at the University of Toledo, is part of a team that sent soybeans on the space shuttle Oct. 29 with Sen. John Glenn. The group wanted to see how a genetic engineering technique designed by Goldman and researcher Anne Graves behaved in weightlessness."*

IFF Tests Fragrance in Space, Soap and Cosmetics, January 1999.

> *"Aboard the NASA Space Shuttle mission STS-95 that lifted off on October 29, 1998 was an unusual passenger -- a miniature rose plant. International Flavors & Fragrances, Inc. (IFF) along with the Wisconsin Center for Space Automation and Robotics (WCSAR), at the University of Wisconsin, Madison, conducted a pioneering experiment during the Shuttle's flight to examine the effects of microgravity on the production of fragrance."*

# SPACE TECHNOLOGY TESTBED

## SPACE TECHNOLOGY TESTBED CONTENTS:

- Satellite Technologies
- Tether Technologies
- Space Solar Power
- Satellite Servicing

Description:

The space technology testbed sector describes using the ISS to test technologies that can be utilized for applications in traditional and emerging space markets. In order to analyze and improve upon the technical aspects of systems and subsystems, or to provide proof of concept testing to conduct R&D in the LEO environment provided by ISS.

Advanced Space System Concepts and Enabling Technologies for the 2000 to 2030 Time Period, by Ivan Bekey for the Aerospace Corporation, 1998.

> This report updates a similar report done by Mr. Bekey in 1976, discusses technologies concepts that apply to NASA, DOD, NRO and commercial interests that could be developed in the 2000-2030 timeframe. The approach taken for this research was wide open with essentially no limiting factors that would preclude any concepts from being evaluated. This document provides a very comprehensive discussion of what is possible in the space arena.

Space Manufacturing 11 The Challenge of Space: Past and Future, Conference Proceedings from the 13th SSI/Princeton Conference on Space Manufacturing, Space Studies Institute, 1997.

> This publication contains numerous papers on the topics of; Asteroids and Nonterrestrial Materials, Transportation and Structures, International, Legal and Economic Considerations, Wireless Power Transmission, Biomedical Considerations and Robotics.

Space Manufacturing and Processing, by the U.S. Dept. of Commerce Office of Air and Space Commercialization, 1996.

This publication discusses the possibilities of developing new materials in space, biotech applications, agricultural applications, the disposal of nuclear waste, space solar power, tourism and other potential commercial space based activities. It also provides discussion of how the ISS, external tank based business parks and the GOEDE project could support and foster the development of such business activities in space.

Space Manufacturing 10 The Challenge of Space: Past and Future, Conference Proceedings from the 12th SSI/Princeton Conference on Space Manufacturing, Space Studies Institute, 1995.

This publication contains numerous papers on the topics of: Transportation, Asteroids and Nonterrestrial Materials, Biomedical, Robotics, Advanced Technologies, Wireless Power Transmission, International, Legal and Economic issues.

## SATELLITE TECHNOLOGIES

Description:
Using the ISS as a testbed to advance technology for communications and remote sensing spacecraft through the development, characterization and validation of spacecraft technology. Using the ISS, satellite technology developers can focus their efforts on the components of interest as opposed to financing, designing, building, integrating and launching tech-demo satellites just to test a specific piece of new space hardware. Additionally, ISS technology development experimenters will have a virtual presence throughout the course of a demonstration, with the possibility of retrieving their hardware for post-test evaluation.

An Engineering Research Testbed for Photovoltaic, Geoffrey A. Landis and Andrew Sexton from the Ohio Aerospace Institute and NASA Lewis Research Center, 1999.

> *"The Ohio Aerospace Institute and the NASA Lewis Research Center are designing and building a solar-cell calibration facility, the Photovoltaic Engineering Testbed (PET) to fly on the International Space Station to calibrate, measure and qualify advanced solar cell types in the space environment. PET will serve three primary functions: calibration, measurement and qualification of solar cells, in order to bring new solar cell technologies to spaceflight readiness."*

Engineering Research and Technology Development on the Space Station, National Research Council, 1996.

> The report discusses the potential for using the ISS as a platform for Engineering Research and Technology Development (ERTD) for conducting tests on materials and systems that must operate in space.
>
> The chapter descriptions from the preface are as follows:
>
> *"Chapter 1 defines ERTD and identifies the principal issues explored in the report. In Chapter 2, the kinds of ERTD that could most appropriately be performed on the ISS are discussed, and a method for setting priorities is proposed. A detailed assessment of the individual fields of research examined by the committee is contained in Chapter 3. Chapter 4 reviews the interface between the space station program and university and industrial experimenters and offers recommendations for facilitating ERTD by these external stakeholders. Chapter 4 also investigates ISS instrumentation, generic facilities and other hardware needed to support ERTD*

*research. The committee reviewed techniques for assessing the benefits of research to U.S. competitiveness but found, as is discussed in appendix B, that none could satisfactorily predict benefits for ISS ERTD. In an effort to provide NASA with more than a negative finding, however the committee in Chapter 5 suggests steps that NASA could take to improve the likelihood that ERTD on the ISS will benefit the economy."*

## TETHERS

Description:

Tether technology uses cables made of high-strength fibers such as Spectra, Zylon, or Kevlar to conduct various functions such as propulsion, space debris removal and power generation. Tethers made of conducting materials can also be used to interact with electric and magnetic fields in space, allowing propellantless propulsion of LEO spacecraft. Tethers are also being considered for use with the Space Shuttle and the ISS for raising or lowering payloads and as a means to reboost the ISS by utilizing the space shuttle during the course of its lifetime.

Tethers Unlimited Inc. Newsletter, April 1999.

- *TUI has also teamed with Boeing and the University of Maryland to complete a Phase I study for the NASA Advanced Concepts Office to work on a Hypersonic Airplane Space Tethers Orbital Launch System (HASTOL).*
- *This award was just awarded in April of 1999.*
- *TUI has also formed a wholly owned subsidiary, Deorbit Inc. to develop the Terminator Tether™ that is being marketed as a system for deorbiting satellites.*
- *Deorbit Inc. has received a $600,000 SBIR Phase II contract for this project and is still looking for investors to raise the additional $3.5 million that is required per their business plan.*
- *Deorbit Inc. has also received endorsement letters from Lockheed Martin, Teledesic and Ellipso as potential users of the Terminator Tether™ system.*
- *Deorbit Inc. is currently finalizing the patent process for 13 tether technology related patents.*

Tether Transport From Sub-Earth-Orbit to the Lunar Surface-and Back!, Robert P. Hoyt and Robert L. Forward of Tethers Unlimited Inc. presented at the International Space Development Conference, 1997.

*"Systems composed of several rotating tethers may provide an economic means of exchanging payloads between the Earth's upper atmosphere and lunar bases with little or no propellant required. The underlying concept is to use long rotating tethers to throw payloads to the Moon and to catch return payloads sent from the Moon. By transporting equal masses to and from the Moon, the total energy and momentum of the system can be conserved. Because the mass of a rotating tether increases dramatically with the DV it can impart to a payload, splitting the lunar transfer boost operation up into two or more stages is necessary to reduce the required tether mass to reasonable levels. This work develops analytical methods for calculating designs for*

*staged tether systems capable of repeatedly exchanging payloads between sub-Earth-orbit and bases on the lunar surface. By properly choosing the design of the system, the total Earth-orbit mass required for a tether system to throw payloads to the Moon, using currently available materials, can be less than ten times the payload mass."*

Applications of the Terminator Tether™ Electrodynamic Drag Technology to the Deorbit of Constellation Spacecraft, Robert P. Hoyt, Robert L. Forward of Tethers Unlimited Inc. and Chauncey Uphoff of Fortune-Eight Aerospace Industries, Inc. presented at the Tether Technical Interchange Meeting, 1997.

*"The Terminator Tether™ is a small, lightweight system that will use passive electrodynamic tether drag to rapidly deorbit spacecraft from low Earth orbit. Studies of the application of electrodynamic drag to the deorbit of constellation satellites indicates that the Terminator Tether™ offers significant mass savings compared to conventional rocket-based deorbit systems. Moreover, because it uses passive electrodynamic drag to achieve deorbit, it can deorbit the spacecraft even if the host has lost power and control functions. Numerical analyses of the performance of the Terminator Tether™ indicate that a five to ten km long conducting tether weighing only 2% of the host spacecraft mass can deorbit a typical constellation satellite within a few months. Although the tether increases the total collision cross-sectional area of the satellite system during the deorbit phase, the electrodynamic drag is so many times greater than atmospheric drag at constellation altitudes that the tether can reduce the collisional Area-Time product for the satellite by several orders of magnitude. The Terminator Tether™ thus can provide a low-cost and reliable method of mitigating the growth of debris in valuable constellation orbits."*

## SPACE SOLAR POWER

Description:

The concept of Space Solar Power (SSP) has been written about, formally studied and debated since the 1970's by numerous organizations and individuals. The concept was originally developed by Peter Glaser, driven primarily by the energy crisis of the time. His design utilized numerous satellites as a means of collecting the sun's energy to be beamed as microwaves to a ground station and then distributed through the existing electrical system. Since that time, there have been many additional system architectures introduced and much discussion regarding the concept.

Space Solar Power: A Fresh Look at the Feasibility of Generating Solar Power in Space for use on Earth, by Science Applications International Corporation, Futron Corporation and NASA, 1997.

> This study discusses the energy markets and issues related to the economics facing the potential development of this technology, several candidate SSP systems and then provides a model for evaluating demand, revenues, performance and costs for the systems. The study also provides several white papers on issues relevant to SSP.

The Promise of Reusable Launch Vehicles for SPS, by Patrick Collins and H. Taniguchi, 1997.

> *"Since the US Department of Energy finished its SPS Concept Development and Evaluation Program in 1981, research on satellite solar power stations has received very little funding from energy research organizations around the world. The main reason for this has been the perception that electricity delivered to Earth from orbiting solar power stations would be too expensive, due to the very high cost of space activities. During the 1990s work within the space industry on developing reusable launch vehicles in order to sharply reduce launch costs has grown considerably. Since the cost of space activities depends primarily on the cost of access to space, this is very encouraging for the prospects of SPS systems. The potential implications of this work for both near-term SPS pilot plants and longer term commercial SPS systems are discussed."*

An Approach to Develop Space Solar Power as a New Energy System for Developing Countries, by Makoto Nagatomo, 1996.

> *"There are many concepts of space solar power systems that have been proposed for space solar energy to be used for humankind. However, most of them were theoretical and not evaluated on*

*the basis of becoming practical power systems. The SPS 2000 study was made on practical assumptions and has indicated a realistic approach to space solar power research which can be interpreted as follows:*

- *To facilitate research on this power system as a future energy source to compete with other sustainable energy candidates, it is necessary to consider the space solar power system as a variation of solar power systems now under research and development for terrestrial use.*
- *The advantage of space solar power over terrestrial solar systems is one order of magnitude larger solar power in space than on the earth. The disadvantage is the high cost of transportation of the required facilities to space. Even if reusable space transportation systems under development realize lower costs, the advantage over terrestrial systems is expected to be marginal. A cost target is therefore mandatory for engineering space solar power stations. The microwave "fuel" concept can be applied to this case too.*
- *It is practical to apply the concept of microwave "fuel" as the interface between space power suppliers and buyers, as utility power suppliers and consumers are related to each other by the standard of commercial electric power. Considering that a properly selected microwave frequency makes it possible for users to plan and even build their rectennas, I strongly recommend the use of 2.45 GHz as a standard for wireless power transmission."*

Beam it Down: How the New Satellites can Power the World, Martin I. Hoffert and Seth D. Potter of NYU and Boeing

This paper describes how Solar Power Satellites (SPS) could be used to provide energy for the world. The authors suggest utilizing the microwaves from the communications satellites that are going to be in service over the next few years to transmit and receive power while utilizing the same infrastructure. The paper then goes on to discuss the potential demand for space solar power (SSP), some beneficial characteristics of SSP and the lack of funding in the U.S. as well as the enthusiasm being given the concept by the Japanese. The next section acknowledges that launch costs are too high and offers some suggestions for mitigating the problem. The final section of the paper suggests some other obstacles to and advantages of SSP technology.

A Few Things You Occasionally Wanted to Know About Wireless Power Transmission, by Seth Potter

*"The design of Solar Power Satellites or a Lunar Power System (LPS) involves beaming energy to Earth, perhaps in the form of microwaves. Unfortunately, the magnitude of such projects has discouraged the planning of demonstrations. In order to understand the physical requirements that tend to push the size of a space power system upward, it is necessary to consider the physics of wireless power transmission, or power beaming."*

## SATELLITE SERVICING

Description:

Satellite servicing concepts are being studied and tested to provide maintenance and repair services for in-orbit satellites. Potential services provided could consist of fixing problems that arise during various stages of the satellites life, make improvements to the spacecraft by changing components or to add fuel to extend the useful life of the spacecraft. Most of the efforts regarding this topic are still being conducted by government agencies.

A Concept for Cost-Effective, Satellite Servicing, Richard W. Madison of Air Force Research Laboratory, 1999.

> *"Air, land and sea vehicles are routinely serviced to increase their availability, flexibility, capability and life span. Servicing could extend the same benefits to satellites, but is rarely employed because current methods are cost effective only for very expensive satellites. This paper presents a concept to minimize the cost of satellite servicing. It combines requirements for a next-generation of serviceable satellites, with an infrastructure whose cost can be amortized over many servicing missions. This should make servicing cost effective for a wider range of spacecraft."*

Supplement to On-Orbit Servicing of Space System, by Donald M. Waltz and Hans F. Meissinger, 1998.

> This update to the original publication published in 1993 provides updates to the recent Hubble Space Telescope servicing missions, new technology developments derived from those missions and plans for future Hubble and other missions. The relevance of ISS commercial activity that can be implied from this document is, that the extensive amount of knowledge, training and technology development that has been gained from the MIR missions and will be gained during the ISS assembly process may contribute to commercial satellite servicing operations at some point in the future.

# MATERIALS AND PROCESSES

**MATERIALS AND PROCESSES CONTENTS:**



Description:

Materials science investigates the relationships among the structure, properties and processing of materials. It is not an industry category nor could it be characterized as a market in and of itself. Materials research is an activity conducted on behalf of numerous industries and serves many purposes. Materials research focuses on improving upon existing materials, creation of new materials, and the improvement upon current or the creation of new processes for their manufacture or use. Microgravity materials scientists seek to use microgravity to study the processes by which materials are produced and the relationships between the formation of a material and its properties. One such method uses containerless processing which eliminates impurities and stresses that are realized when the material comes in contact with container walls.

Processes research is aimed at determining and improving upon various physical phenomena that are key to many NASA missions and industrial business activities. Like materials research, processes research can be applied to a number of industries for many different purposes.

Materials Development Opportunities, Charles A. Lundquist of The Consortium for Materials Development in Space at the University of Alabama Huntsville, 1999.

> *"Commercial materials development opportunities on the International Space Station have been the subject of extensive discussions over many years. Most of these have addressed specific examples. However, this discipline is reaching a level of maturity such that a more penetrating analysis of space opportunities is timely. A categorization is presented that first identifies three classes of results and second notes four economic traits. Each specific development opportunity can be placed in a matrix position dictated by the class of its results and by its economic trait."*

Space Product Development Experiment Module Utilizing the ISS, Christine Watson, Charles Lundquist, Francis Wessling, James Smith and Robert Naumann of The Consortium for Materials Development in Space at the University of Alabama Huntsville, 1999.

> *"Furnace facilities for materials processing on the International Space Station (ISS) will include the Space Product Development Experiment Module (SPDEM) which includes a transparent Furnace Module and an opaque Furnace Module. The SPDEM is scheduled currently for UF-3 aboard the Materials Science Research Rack (MSRR). Various commercial interests can be satisfied sequentially by scheduled employment of the SPDEM. The CMDS will be the facility manager through whom arrangements can be made for SPDEM access. The ISS should provide long growth periods which are needed to grow large single crystals in microgravity. A typical area of commercial interest is acousto-optic filters (AOTF), based on mercurous halide research which would continue on the ISS, research begun on the STS-77 mission. Another area of commercial interest planned for implementation on ISS is liquid metal sintering of composites to further improve techniques for making better quality materials."*

Levitating Furnace for Micro-G on ISS, Spacedaily, 1999.

> This news article discusses a levitating furnace facility called TEMPUS that was created by the German Space Agency. This facility is designed to conduct containerless research for metals and alloys. It has been flown on MSL-1 and IML-2 and has provided highly consistent data which is valuable for this type of research.

Promise of True Holographic Projection, Spacedaily, 1999.

> This new article discusses a Hungarian materials research furnace that may end up on the ISS. The Universal Multi-Zone Crystallizator can be used for semiconductor, laser and optics research.

Engineering Competitive Materials, James C. Williams, The Bridge 1998.

> This paper discusses the use of computational and analytic tools to conduct materials and materials processing research. The process and requirements for discovering new materials is also outlined.

Revolutionary Microgravity Processing Capability is Goal of new Joint Venture; SPACEHAB and Guigne Technologies Perfecting "Containerless" Processing Method, SPACEHAB, 1998.

This press release discusses the joint venture between the two companies to develop, manufacture, market and sell the service of the Space-DRUMS facility. The new facility for use on Shuttle and ISS can be used for alloy, semiconductor, glass and ceramics, crystal growth and fluid physics research.

Future Materials Science Research on the International Space Station, National Research Council, 1997.

This NASA requested study discusses several issues regarding the ISS's Space Station Furnace Facility (SSFF) Core. The study was to (1) examine NASA's research plan for high-temperature, microgravity materials science; (2) assess the ability of the current SSFF Core concept to support the range of high-temperature experiments and associated specialized furnaces; (3) evaluate the usefulness of the planned high-temperature microgravity materials-science projects and developed technologies to the research and industrial materials-science communities in terms of already identified need and planned activities through the year 2010; (4) assess the ability of NASA's high-temperature microgravity materials-science plan to accommodate evolving interests and priorities in the field of materials science; and (5) examine the procedures used by NASA to select experiments for the ISS and determine if they encourage active participation by the broader materials-science research community.

Findings and recommendations of the study:

- Need to improve or create new systems to handle g-jitter.
- Provide more information to potential researchers regarding the SSFF Core concept.
- System design should not be the characteristic that determines which programs get selected but rather those that benefit science, technology, engineering and society in general.
- NASA should ensure that perceived flight availability does not influence the initial proposal review portion of the process.
- The microgravity materials-science program must be proactive in developing an effective outreach program to encourage more proposals from disciplines that currently are under represented.
- The SSFF Science Working Group (SWG) should be comprised of individuals with

expertise in all materials subjects. Protocols to ensure objectivity and independence of SWG members should be created.

- The SSFF should be modified to allow for a greater range of materials science programs.
- More focus should be given to polymeric, glass and ceramic materials research.

## ELECTRONIC AND PHOTONIC MATERIALS

Description:

Electronic materials are used to transmit signals by way of electrons. Manufacturers are beginning to reach the physical limits of what they can do with ordinary silicon-based materials, and as a result are regarded as an area that could be improved by study in microgravity (e.g., new areas of fabrication such as molecular beam epitaxy, or new semiconducting materials). Many large corporations, industry consortiums and government agencies are conducting terrestrial research in the area of semiconductors.

Photonics is the optical equivalent of electronics, and the two technologies coexist in such innovations as optoelectronic integrated circuits. Photonic applications include data storage such as optical disks and holograms, data transmission such as fiber optics, cell phones and pagers. Photonic materials such as Gallium Arsenide, Silicon Germanium and Silicon Carbide are examples of compounds being used to improve the capability of semiconductors. Scientists and engineers are working to combine photonics with other technologies to facilitate growth of the economies' largest growing industry information technology. Continued development of information technologies is dependent on the integration of photonics and electronics.

Semiconductor Materials Research Needs for the 21st Century, Paul S. Peercy of SEMI/SEMATECH, The Bridge, 1998.

This paper discusses the current trends in the semiconductor industry and the requirements for improving the materials that are used to manufacture products such as integrated circuits (IC). The discussion focuses on, silicon-based ICs. Mr. Peercy notes that in 1997 $2 billion was spent on materials for semiconductors in the U.S. An industry driver behind the need for material research in this area is the need to make products smaller and faster. In order to meet the demand for smaller and faster products new manufacturing techniques will be required and new materials to manufacture with thus the need for research in this area.

## CERAMICS

Description:

Ceramic materials are made from nonmetallic inorganic minerals. Ceramics are noted for their lightweight, hardness, and resistance to corrosion and high temperatures. Glass is one of the most basic of ceramic materials. It is the only material that is transparent, resistant to heat, and able to hold a vacuum inside all at the same time.

Most ceramic synthesis and processing is done at high temperature either by solid-state processes exclusively or by processes in which there are only small amounts of viscous liquid phases. Because the microgravity environment is more important in systems that contain liquids, microgravity research in ceramics tends to be less prominent than in other materials areas.

Applications for ceramics include:

- Aircraft and automotive engine components
- Gas turbine components
- Thermal protection systems
- Hot gas filters and radiant burners
- Fiber optics for telecommunications
- Scaffoldings for tissue growth
- Composite structures
- Electronics
- Prosthetics and other medical applications
- Thermal, electrical, environmental and ballistic insulation
- Environmental cleanup and filters
- Joints and bearings

Recent Microgravity Results in the Synthesis of Porous Materials, X. Zhang, D.P. Johnson, A.R. Manerbino, J.J. Moore, and F.D. Schowengerdt, 1999.

> *"Porous ceramics produced by reaction synthesis can be engineered to meet the strength and porosity requirements of a consumer, such as for the application of bone replacement materials. Control parameters such as ambient pressure, dilutents, green density, gasifying agents and gravity can be used to effect desired product properties to mimic those same properties of natural bone, enabling growth into the implant."*

Porous Ceramics Preliminary Technology Transfer Assessment, Colorado Venture Centers Inc., 1998.

The Colorado Venture Center (CVC) on behalf of the Colorado School of Mines Center for Commercial Applications of Combustion in Space conducted this preliminary assessment to analyze the potential for ceramic products synthesized by using self-propagating high-temperature synthesis. The two primary applications discussed were for filters and catalyst substrates and bioceramic medical applications.

The Potential of Advanced Ceramics, Roger G Ackerman, CEO of Corning Inc., 1997.

This speech given to the United States Advanced Ceramics Association discusses some of the issues regarding the early development of fiber optics and automobile catalytics. He goes on to discuss new areas of interest such as lenses made from fused silica that are used to manufacture semiconductors, glasses for large telescope mirrors, filters and oxidizers and newer catalytic materials. Mr. Ackerman suggests that given time advanced ceramics will be beneficial to many industrial applications and societal problems.

## METALS AND ALLOYS

Description:

Traditional metals include commodity alloys of elements such as iron, nickel, and aluminum. Advanced metals tailored for specialty application include lightweight magnesium alloys; specialty tool steels and nickel-based alloys; refractory alloys; and high-temperature, high-strength inter-metallics.

During the course of our research we found no publicly available reports that specifically address the paid commercial utilization of the ISS for research based on the criteria established for this study.

## POLYMERS

Description:

Polymers are large molecules consisting of long chains of repeated units. Polymers potentially represent the broadest classes of engineered materials, permitting great innovation and precision in design down to the molecular level. Polymers are noted for unique combinations of properties and have a range of applications, from plastic containers to liquid crystal displays. Plastic wrap and Kevlar bulletproof vests are some common examples. Polyimides are advanced, high-temperature polymers used for electronic packaging and aircraft skins.

During the course of our research we found no publicly available reports that specifically address the paid commercial utilization of the ISS for research based on the criteria established for this study.

## COMBUSTION

Description:
Combustion science aims to improve the understanding of the fundamental energy transformation process and gain new insight into its physical dynamics. By better understanding the fundamentals of combustion, researchers may develop more accurate models, leading to increased efficiencies in commercial applications.

Space enables the collection of the measurements needed to understand and resolve practical combustion problems. These measurements are most easily made on large, steady, slow-moving, and symmetric flames that provide good time and space resolution. These simplified flames are not present on Earth because convection cause flames to take on their characteristically elongated shape.

Commercial Combustion Research Aboard the International Space Station, F.D. Schowengerdt of the Center for Commercial Applications of Combustion in Space at the Colorado School of Mines, 1999.

> *"The Center for Commercial Applications of Combustion in Space (CCACS) is planning a number of combustion experiments to be done on the ISS. These experiments will be conducted in two ISS facilities, the SpaceDRUMStm Acoustic Levitation Furnace (ALF) and the Combustion Integrated Rack (CIR) portion of the Fluids and Combustion Facility (FCF). The experiments are part of ongoing commercial projects involving flame synthesis of ceramic powders, catalytic combustion, water mist fire suppression, glass-ceramics for fiber and other applications and porous ceramics for bone replacements, filters and catalyst supports. Ground and parabolic aircraft-based experiments are currently underway to verify the scientific bases and to test prototype flight hardware. The projects have strong external support."*

Money in Microgravity, Aerospace Daily, 1997.

> This article references the Ring Flame Stabilizer researched by scientists while on board the Space Shuttle. The stabilizer increases home furnace efficiency by 2% while cutting oxide emissions by a factor of 10.

## FLUID PHYSICS

Description:

The behavior of fluids is fundamental to many phenomena in materials science, biotechnology, and combustion science. For instance, the performance of power plants depends on the flow characteristics of vapor-liquid mixtures. Oil recovery from partially depleted reservoirs depends on how liquids flow through porous rocks. The safe engineering of buildings in earthquake prone areas requires an understanding of fluid-like behaviors of soils under stress.

Many of our intuitive thoughts about fluids do not hold up in orbit because of forces that are normally masked by gravity, such as surface tension, control fluid behavior in microgravity. For example, surface tension causes drops to form spheres in zero gravity. Differences in fluid behavior offer scientists and commercial researchers unique opportunities to explore different aspects of the physics of fluids.

During the course of our research we found no publicly available reports that specifically address the paid commercial utilization of the ISS for research based on the criteria established for this study.

# ENTERTAINMENT

**ENTERTAINMENT CONTENTS:**

- Sound Stages
- Space Athletic Events
- Space Tourism
- Space Theme Park

Description:

The entertainment industry will play an important role in raising worldwide awareness of the ISS. A large percentage of the world's population is not currently aware of the existence of the ISS, let alone its function and role. Based on the number of recent films based on space reality, it is likely the ISS will appear in numerous films, television, print media and internet events. The role of ISS in this field will be as the hub of space-theme entertainment (e.g., a featured location).

The three most probable domestic entertainment industries in a position to involve the ISS in their content are television, motion pictures and internet. The first two sectors dominate the creation and distribution of entertainment content consumed worldwide. The internet, however, is becoming an increasingly popular distribution pipeline for both passive entertainment content as well as interactive content.

## SOUND STAGES

Description:

The on-orbit sound stage would be developed based on the need of earth-bound entertainment and other content creation firms to film sustained and believable live action microgravity scenes. While capabilities of the digital special effects industry have come a long way in the last several years, it is still extremely difficult to generate digital special effects which accurately mimic a live human actor in microgravity.

External shots of deep space, the celestial bodies, the planets in the solar system create excellent sources of stock footage for print, films, internet, and television drama and news. This stock footage can be used as either backdrop or the raw data for digital special effects.

IMAX Corporation Home Page

BLUE PLANET (1990: 42 Minutes)

A presentation of the Smithsonian Institution's National Air and Space Museum and Lockheed Martin Corporation, in cooperation with the National Aeronautics and Space Administration. Filmed in space by the Astronauts. Produced by Graeme Ferguson, IMAX Space Technology Inc., for the Smithsonian Institution's National Air and Space Museum and Lockheed Martin Corporation. Principal Director: Ben Burtt. Writer, Editor and Narrator: Toni Myers.

Blue Planet, a space film about Earth, gives us an experience of our home planet that, until now, has only been shared by astronauts. Spectacular scenes from space, filmed aboard several space shuttle missions, are intercut with scenes of the Earth's surface, clearly showing the powerful forces that affect our planet. Volcanoes, earthquakes and typhoons are depicted--but it is the signs of pollution, ozone depletion, deforestation and energy consumption as seen from space that reveal the more disturbing human impact. The Washington Post says, "If a picture is worth a thousand words, any one scene from Blue Planet is worth a zillion."

MISSION TO MIR (1997: 40 Minutes)

IMAX Corporation and Lockheed Martin Corporation in association with the Smithsonian Institution's National Air and Space Museum present "Mission To Mir" filmed in space by the astronauts with the co-operation of the National Aeronautics and Space Administration (NASA). Director (Russia) Ivan Galin; Director of Photography James Neihouse; Music by Micky Erbe and Maribeth Solomon; Executive Producers Andrew Gellis and Jonathan Barker; Producers Toni Myers and Graeme Ferguson

American astronauts and Russian cosmonauts have joined forces 200 miles above the Earth as the space shuttle links with Space Station Mir. In Mission to Mir, IMAX® cameras have captured the excitement and emotion of these dramatic events which herald the next age of space exploration.

Putting aside the days of the Cold War, we go behind the scenes of the Russian space program which was, until recently, accessible only to a few. Now we can explore Star City where Russians and Americans together are preparing for upcoming missions; thrill to a thunderous Soyuz launch at Baikonur; and witness the in-orbit drama of the Mir-Shuttle rendezvous.

Lights, camera, liftoff - it's Mir, the movie: Florida Today, November 5, 1997.

"The year is 1999 and it's a sad day for Russia's space program. The Russians are turning out the lights on their beloved Mir space station and bringing home the last cosmonaut.

But wait. There's one last snag. A renegade cosmonaut insists on remaining aboard, declaring he will orbit the earth for the rest of his days. Ground controllers order him home, then plead and beg, but can't persuade the maverick spaceman to abandon ship. The last-ditch plan: Send up a woman to lure him back.

As if there hasn't been enough high drama on the Mir in recent months, Russian film director Yuri Kara is pushing to make a movie - with real actors aboard the space ship - before the Mir is discarded in about two years."

CNN's John Holliman headed for visit to Mir? Florida Today, October 29, 1997.

"The Tokyo Broadcasting System paid the Soviets $12 million to send news director Toyohiro Akiyama on an eight-day Mir mission in December 1990. He was the first, and so far only, journalist to fly in space."

## SPACE ATHLETIC EVENTS

Description:

Conceived as one of the markets for future space entertainment in the CSTS Final Report, the concept is to hold regular sporting events in an on-orbit facility, with a down-link for live international television broadcast. There are unique attributes of space athletic events that may generate significant levels of interest amongst earth-based audiences. New forms of sporting events would have to be created to take advantage of the unique characteristics of microgravity, whether they be derived from existing events (e.g., space soccer) or created as entirely new sport.

Artificial-Gravity Swimming Pool, Patrick Collins, Sunao Kuwahara, Tsuyoshi Nishimura, Takashi Fukuoka, Journal of Space Technology and Science, NASDA/Hazama Corporation, 1997.

> *"One of the uses that has been proposed for fully reusable launch vehicles is "space tourism", the making of short visits to low Earth orbit by fare-paying passengers. This seems to offer the potential to generate a large commercial market, of the order of tens of launches per day, which could amortize the development cost of a new generation of reusable launch vehicles. Recently there has been a considerable increase in research concerning this possibility, with an international symposium being held in Bremen, Germany in March 1997, a session being held on the subject for the first time at the 1997 IAF Congress, the Space Transportation Association in Washington, D.C. publishing a report on it in collaboration with NASA, and the AIAA holding a workshop on the subject in January 1998, among other activities.*
>
> *Once businesses start to offer travel services to low Earth orbit, it is expected that orbiting "hotels" will be developed to enable guests to enjoy a variety of entertainment in Earth orbit. One feature of such hotels will be sports centers providing guests the opportunity to enjoy moving about freely in weightlessness, or "zero gravity". This paper considers one possible facility in such a sports center, namely a rotating, artificial-gravity swimming pool."*

Design and Construction of Zero-Gravity Gymnasium, Patrick Collins, Sunao Kuwahara, Tsuyoshi Nishimura, Takashi Fukuoka, Tokyo University/Hazama Corporation, 1997.

> *"In the future, as orbiting hotels become more sophisticated more advanced facilities will be developed. One direction of such development will be to include larger rooms for guests to experience activities in "zero gravity", as it is popularly known. The paper considers the design of a small gymnasium that might be the first of such sports centers to be built and used in orbit."*

## SPACE TOURISM

Description:

In the area of human space flight, the projected markets for space tourism appear enormous, given the right circumstances (e.g., radically lower cost to orbit, enhanced safety). According to a recent study on space tourism, the total US market for travel and tourism exceeds $400 million per year. It was described by the CSTS as the largest industry in the world with economic participation by a spectrum of companies ranging from multi-national corporations to individual entrepreneurs.

Branson Boldly Goes into the Space Business: The Sunday Times, March 29, 1999.

> *"NEVER lacking ambition, British entrepreneur Richard Branson wants to extend his business empire into the stratosphere and claim space as Virgin territory. Mr. Branson will this week launch his most ambitious project yet as Virgin Galactic Airways begins its eight-year mission to make space the next tourist hotspot.*
>
> *The entrepreneur has been in negotiations with the Rotary Rocket Company, a US space-plane designer, to sell the first civil space experience. The space-plane is being designed as a reusable eight-seat craft that will provide those paying about $US 100,000 ($157,000) a trip the opportunity to experience weightlessness and view the curvature of Earth..."*

Space Adventures Inc. Offers Bookable Adventures in Space Now, Company Press Release, September, 1997.

> *"Space Adventures will offer microgravity simulation flights domestically. This organization is backed by two travel companies, Omega World Travel and Quark Expeditions. The companies' current offerings include rides on Russian MiG-25 Foxbat fighters for $12,000 per ticket and micro-gravity simulation flights in Russia at a cost of $5,500 per ticket. This organization is also taking deposits for suborbital flights.*
>
> *Do away with gravity in a zero-gravity aircraft, or climb to the outer rim of the Earth's atmosphere in a Russian MiG 25 -- two giant "Steps to Space" ™ that can be booked today with Space Adventures Inc.*
>
> *Joining forces in the new venture are Virginia-based Omega World Travel, Connecticut-based Quark Expeditions and a prestigious Advisory Board including four former astronauts."*

### Spacetopia

*"Spacetopia Inc has been established to exploit the emerging market for space tourism and related services in Japan. It will also participate in other commercial space activities that will arise with the sharp reduction in launch costs that space passenger travel will bring about.*

*Founded by partners with extensive knowledge of both the Japanese travel market and global efforts to bring space tourism services to reality, Spacetopia Inc will have three main fields of activity - travel, media, and business services.*

*Spacetopia is a unique gateway to Japan for non-Japanese companies looking to participate in this field - whether seeking partners, aiming to serve the Japanese market, or requiring consultancy on specific projects."*

### Zegrahm Space Voyages

*"Zegrahm Space Voyages announces an unprecedented travel adventure once thought unattainable to the general public: a complete space experience culminating with an actual flight to space.*

*Zegrahm Space Voyages, a division of the Zegrahm Expeditions travel company, is taking reservations for departures that begin July through December, 2002.*

*Our aerospace partner has developed the vehicle technology to take you up to 100 km — official "astronaut altitude" — where weightlessness can be experienced and the Earth's curvature provides the backdrop. We've integrated this flight into a remarkable 7-day travel program that will immerse you in space exploration, just as we immerse our expedition travelers in destinations like Antarctica, Africa, the South Pacific and Madagascar."*

### Sharespace Foundation

The Sharespace Foundation, founded by Apollo 11 astronaut Buzz Aldrin is a "cooperative" venture where participants will contribute "as little as $10" for chance to ride into space. In joining the cooperative, each participant gets an ongoing chance to be randomly selected for training as astronauts and a ride into space on a next generation space vehicle. For those that do not make the final selection process, alternative chances are available for sub-orbital flights, zero-g flights, tours of space facilities, and attendance at domestic and international launches.

*"The Sharespace Foundation has a solution to these problems that will give ordinary citizens with ordinary means the chance to fly in space, possibly before the next generation passenger flying space vehicles come into service. Sharespace seeks to create a cooperative whereby any citizen can contribute as little as $10 dollars and have the opportunity to fly in space.*

*Sharespace will select a pool of potential astronauts by random selection from those who choose to participate. After appropriate medical screening, these candidates will have the opportunity to train and compete for a ride into space. Those who are selected as potential astronauts, but who are not selected to fly, will nevertheless get to participate in the space program. They will receive alternative benefits, possibly including sub-orbital flights, zero-g flights, tours of space facilities, and attendance at launches in the U.S. or abroad.*

*Unlike a traditional random selection process, the Sharespace cooperative will allow ongoing participation. In other words, by joining with as little as a single $10 contribution, a participant would be eligible for future drawings. Furthermore, association with Sharespace would make the participant a member of a larger movement and entitled to other benefits."*

Japanese Pepsi Drinkers Could Win a Trip to Space in 2001, Reuters, Wired Magazine, Yomiuri Shimbun, April 21, 1998.

*"Reuters and Wired Magazine are reporting that the Japanese distributor of Pepsi, Suntory Ltd., plans to offer its customers the chance to fly in space as part of a promotional campaign. Five winners will receive the opportunity to fly into space in 2001 via Zegrahm Space Voyages, a U.S. space travel agency."*

Teacher's Dream as a Pilot to be Fulfilled With Russian MiG Flight, X Prize ® Foundation Press Release, October 29, 1998.

The X Prize Foundation is promoting a contest through its affinity credit cards. A small portion of the proceeds will go to the X Prize, and the credit card customer will have his/her name automatically entered into a sweepstakes. The awards include hundreds of flights on a MiG-25 and the grand prize will be a sub-orbital flight on board one of the vehicles vying for the X Prize. The sweepstakes winners will be announced after the X Prize has been won.

*"Buck, a special-education teacher from Davison, Mich., will soon travel to Moscow and up to 85,000 feet at two-and-a-half times the speed of sound aboard a Russian MiG-25 as the first winner in the YOUR TICKET TO SPACE (SM) sweepstakes. The first-of-its-kind quarterly sweepstakes is sponsored by the X Prize ® Foundation, a nonprofit organization created to jump-start the space-tourism industry."*

Hotels in Space, Barron Hilton, 1967.

*"The possibility of an orbiting or lunar hotel is discussed. It is suggested that when space scientists make it physically feasible to establish hotels in space and to transport people, the hotel industry will meet the challenge."*

Demand for Space Tourism in America and Japan, and its Implications for Future Space Activities, P. Collins, R. Stockmans, and M. Maita, 1995.

*"In 1995 market research on the potential demand for space tourism has been carried out in the USA and Canada, supported by the National Aerospace Laboratory in Japan. Although estimates have been published before, this is the first actual market research of its type to be done on the North American market. This paper describes the research, and compares the data with earlier research conducted in Japan. Although there are a number of differences in the results, they are broadly comparable to those in Japan, which suggests that space tourism services would also be very popular in North America. The paper then considers the implications of this research for future space activities and space transportation systems."*

General Public Space Travel and Tourism - Volume 1 Executive Summary, NASA/ Space Transportation Association, March, 1998.

*"Travel and tourism is one of the world's largest businesses. Its gross revenues exceed $400 billion per year in the U.S. alone, and it is our second largest employer.*

*The first professional space tourism market studies have been conducted in several countries in the past few years, especially in Japan and here. The U.S. Study makes it clear that, conceptually, tens of millions of us would like to take a trip to space if we could do so with reasonable safety, comfort and reliability, and at an acceptable price. Initial businesses will address the desires of those willing to pay a greater price and accept a greater risk."*

Practical Tourism in Space, Samuel M. Coniglio, Space Tourism Consultant, 1996.

*"The World Travel Tourism Council estimates that 1995 revenues for tourism worldwide was $3.4 trillion. The city of Orlando, Florida has one of the largest tourism centers in the United States, including Walt Disney World, Universal Studios, and Sea World. In a recent economic impact study, Orlando received an economic impact of $13.1 billion from theme parks, hotels, restaurants, and shopping centers.*

*This paper will discuss two projects which a major entertainment or tourism corporation could get involved in immediately. First, cross-industry communication can be initiated through conferences between leaders of the hotel, tourism, entertainment, aerospace and other industries. Second, the dream of recreational space travel can be brought closer to reality through a phased approach, starting with sponsorship of the X-Prize contest, by developing simulator rides and virtual reality shows based on actual space projects, and soliciting bids for constructing space cruise ships and an orbital hotel."*

Report of Working Group No. 4 of the AIAA/CEAS/CASI Workshop on International Cooperation in Space: The working group on public space travel, Ivan Bekey, January, 1998.

*"Mandate to recommend steps that should be taken internationally to enable and facilitate travel to and from space for the general public.*

*Extensive travel by air, sea and land for pleasure and business has become a commonplace fact of modern life. By contrast, travel in space is available to only a few highly trained government astronauts, and the public's perception is that it cannot be otherwise. In fact, "space tourism", routinely available to the general public at affordable prices, is much closer at hand than most people realize. It is sure to become a huge commercial space industry in the near future."*

Economically Viable Public Space Travel, Ivan Bekey, 49th IAF, October 2, 1998.

*"This paper presents the results of new study by the author that analyzed the potential market for Public Space Travel (PST), defined a set of optimum launch vehicles for this service, and set up a series of paper businesses to take as few as 100 and as many as 1,000,000 people into space annually. To enable the analyses, the study analyzed market surveys done to date and derived a "most likely" market elasticity model."*

A Common Cost Target of Space Transportation for Space Tourism and Space Energy Development, Makato Nagatomo, Patrick Collins, ISAS/NASDA, July 18, 1997.

> *"In this paper, we have selected two commercial activities, tourism and satellite solar power stations, of which the space transportation requirements are realistically predictable in economic terms. Space tourism is considered as part of the tourism industry - a global business which has driven the development of the civilian aerospace industry since WW2, and which seems large enough to continue to support the aerospace industry in the post cold-war era. Even though the scale of space tourism activities may be much smaller than the airline industry, it is assumed that similar operating concepts will be applied to these new services. The business of satellite solar power stations considered here is to build solar power satellites in low equatorial orbits and sell microwave power to ground-based electric utility companies. The upper limit of the costs for the system will be determined by the price competition of other electricity sources."*

Artificial Gravity and the Architecture of Orbital Habitats, Theodore W. Hall, Department of Architecture, University of Hong Kong, 1997.

> *"This paper examines the rationale, requirements, limitations and implications of artificial gravity in the design of orbital habitats. Long-term exposure to weightlessness leads to a chain-reaction of undesirable physiological adaptations. There is both theoretical and experimental evidence that artificial gravity can substitute for natural gravity to maintain health in orbit. Aerospace medical scientists have conducted many studies during the past forty years to determine the comfort boundaries for artificial gravity. They express comfort in terms of centripetal acceleration, head-to-foot gravity gradient, angular velocity, tangential velocity, cross-coupled head rotations and the Coriolis effects of relative motion in rotating environments."*

Next Space Race: Tourism, Jennifer Hillner, Wired News, February 23, 1998.

> *"Almost two years after a St. Louis, Missouri, nonprofit organization offered $10 million to the first private company to take tourists into space, several serious competitors are testing their hardware and aiming for a launch window around 2001.*
>
> *"Let's not wait another 50 years before we get regular people into space," said Diane Murphy of the X Prize Foundation, which in May 1996 put up the prize to hurry along the development of commercial space flight. The foundation's $10 million purse will go to the creator of the first private reusable spaceship capable of carrying three humans 100 kilometers above the Earth on two consecutive flights within two weeks..."*

X PRIZE Foundation

*"The X PRIZE was founded on 18 May 1996 in St. Louis for the specific purpose of stimulating the creation of a new generation of launch vehicles designed to carry passengers into space. Today if you are interested in flying there are only two options, the US Space Shuttle or the Russian Soyuz, and neither of these are available at a reasonable cost or on a regular basis to the general public. The problem is not the lack of financial resources among today's adventure tourists, nor the demand in the marketplace, but specifically the lack of licensed, low-cost, reliable vehicles. Taking a lesson from the history books, we modeled the X PRIZE after the early aviation prizes. Between 1905 and 1935, hundreds of aviation prizes stimulated the creation of very different aircraft designs, each of which explored different regions of flight and different mechanisms for optimizing speed, safety and low cost travel. Today the X PRIZE is doing the same. Since our inception three years ago over 16 teams have registered for the competition and we have raised over $5M towards the prize."*

## SPACE THEME PARK

Description:

The long-term goal of building an on-orbit facility to house and provide entertainment to visiting tourists is envisioned as a significant mass-market application for space. It is possible that terrestrial "Space Theme Parks" will pave the way as Earth-based counterparts to the eventual on-orbit facilities. The terrestrial parks will have extensive facilities to re-create the space experience on the ground. Additional revenues will be generated from licensing and merchandising tie-ins to the theme parks and government and commercial space companies.

Terrestrial space theme parks exist on a global basis today and are quite successful. They come in a variety of forms, (e.g., space-oriented museums to space research, launch and recovery centers, and space camps).

The Kennedy Space Center Visitor Complex, Florida

*"The Kennedy Space Center Visitor Complex provides an exhilarating and educational experience of the space program.*

*Whether touring the Rocket Garden, or boarding a full-scale replica of the Space Shuttle Explorer, visitors are guaranteed to gain a new perspective on the incredible feats accomplished by the space program.*

*The Visitor Complex also offers amenities and services such as bus tours, restaurants, first-aid, and pet kennels. Admission to the Kennedy Space Center Visitor Complex is free; there are nominal charges for bus tours and IMAX® films.*

*The Kennedy Space Center Visitors Center in Florida and the Space Center Houston in Texas operate full service entertainment centers with the space "experience" mixed with tours of NASA facilities, museums and gift shops."*

The National Air and Space Museum Washington, DC

The National Air and Space Museum draws over 10 million people per year.

*"The Smithsonian Institution's National Air and Space Museum (NASM) maintains the largest collection of historic air and spacecraft in the world. It is also a vital center for research into the history, science, and technology of aviation and space flight. Located on the National Mall in Washington, D.C., the Museum has hundreds of artifacts on display including the original Wright 1903 Flyer, the "Spirit of St. Louis," Apollo 11 command module, and a Lunar rock sample that visitors can touch. The museum continues to develop new exhibits to examine the impact of air and space technology on science and society."*

Spaceport Kansas: A Visit to the Kansas Cosmosphere and Space Center, Jeff Foust

*"Hutchinson, Kansas usually doesn't make anyone's list of cities with an influential space presence. Jeff Ollenburger wants to change that.*

*"We are planning to become the most comprehensive space museum in the world," Ollenburger, marketing coordinator for the Kansas Cosmosphere and Space Center, said in a recent interview. "That's our goal."*

*While the Cosmosphere lacks the publicity of the Smithsonian's Air and Space Museum or NASA centers in Houston or Florida, it makes up for it with an impressive display of space artifacts that will soon be bolstered by a multi-million dollar expansion project which will triple the amount of display space available. By the end of the this year, when the expansion project is completed, only the Air and Space Museum will have a larger collection of space artifacts than the Cosmosphere.*

*The Cosmosphere, which attracted over 300,000 visitors from the U.S. and 60 other countries last year, combines its collection of American and Soviet space artifacts with an ambitious educational program that include a SpaceCamp-like summer program, the only OMNIMAX theater in the state, and the Justice Planetarium, the newest and largest planetarium in Kansas. Put together, they make the Cosmosphere the best space museum in the Midwest, and among the best in the country".*

Gorky Park, Russia

The Buran shuttle ride in Moscow, Russia, was added to the variety of other attractions at the famed Gorky Park. It appears that the ride is an actual test vehicle that has been outfitted with zero-gravity simulation seats. The ride consists of a short multi-media presentation with live-action flight attendants.

# EDUCATION

**EDUCATION CONTENTS:**



Description:

Private sector for-profit initiatives in education can be significant beneficiaries of the ISS program in two important ways. First, educational curricula can be developed based on the research conducted on-board the ISS. Secondly, on-orbit facilities may be used to generate lectures from space that may then be used as classroom material (e.g., space, earth and life sciences).

## EDUCATIONAL DEVELOPMENT FROM ISS RESEARCH

Description:

Private sector education initiatives surrounding ISS research represent potential commercial markets where NASA expenditures could be reduced. For this commercial market to appear, private organizations must be willing to commit resources to enable space education based on ISS research, either through their marketing or public relations budgets.

Industry has proposed several corporate sponsorship initiatives to answer NASA's request for more industry participation in meeting its ISS education goals.

The International Space Station: An Opportunity for Industry-Sponsored Global Education, Cathleen E. Shields, The Boeing Company, 1999.

> *"In 1996, Boeing began exploring the possibility of developing an international space education program that would utilize existing space assets and then transition to the International Space Station upon assembly complete. The effort was initiated for two reasons: (1) to bring corporate money into human space utilization, and (2) to perform outreach for NASA. It was believed that the private sector would sponsor education in space if the program were creative and exciting, if the educational value was compelling, and if the sponsorship benefits were attractive and achievable. We believed that few organizations would walk away from the opportunity to bring education to the children of the Earth."*

S*T*A*R*S - Utilizing Space and Space Research for Educational Initiatives, Kimberly A. Campbell, SPACEHAB, 1999.

> *"SPACEHAB, Inc., the leading commercial space services company, along with the Center for Microgravity Automation Technology, offers an exciting educational opportunity to conduct microgravity research aboard a variety of vehicles. SPACEHAB has established a "Microgravity Staircase," a comprehensive portfolio of ground-based, sub-orbital and space-based microgravity research facilities designed to meet a variety of needs and budgets. Via the Microgravity Staircase, the S*T*A*R*S Program provides research opportunities aboard a variety of platforms to the academic community. Each step in the staircase offers a different duration of microgravity exposure, providing students and educators steadily increasing periods of microgravity. Whether a given experiment requires a 20-second ride on a parabolic aircraft, a 15-minute trip aboard a sub-orbital rocket, or a long-duration stay on an orbiting platform, SPACEHAB has the ability to provide academic opportunities and servicing before, during and after flight."*

## EDUCATIONAL PROGRAMMING

Description:

The educational programming that will be generated on the ISS through a variety of sources is likely to find significant terrestrial markets. There will be global access to educational programming produced on ISS or about ISS which will be distributed through any number of channels (television, internet, radio, videotape, written classroom curriculum, live presentations, etc.). It is not clear as to whether for-profit educational organizations will be the primary generator of ISS-related educational programming, or whether these tasks will be limited to non-profit and governmental organizations only.

Corporate Sponsored Education Initiatives on Board the ISS, Ian T. Durham, Alyson S. Durham, James A. Pawelczyk, Lawrence B. Brod and Thomas F. Durham, 1999.

> *"This paper proposes the creation of a corporate sponsored "Lecture from Space" program on board the International Space Station (ISS) with funding coming from a host of new technology and marketing techniques. Astronauts in residence on board the ISS would conduct short 10 to 15 minute live presentations and/or conduct interactive discussion carried out by a teacher in the classroom. This concept is similar to a program already carried out during the Neurolab mission on Shuttle flight STS-90. Building on that concept, the interactive simulcasts would be broadcast over the Internet and linked directly to computers and televisions in classrooms worldwide. In addition to the live broadcast, educational programs and demonstrations can be recorded in space, and marketed and sold for inclusion in television programs, computer software, and other forms of media. Programs can be distributed directly into classrooms as an additional presentation supplement, as well as over the Internet or through cable and broadcast television, similar to the Canadian Discovery Channel's broadcasts of the Neurolab mission. Successful marketing and advertisement can eventually lead to the creation of an entirely new, privately run cottage industry involving the distribution and sale of educationally related material associated with the ISS that would have the potential to become truly global in scope. By targeting areas of expertise and research interest in microgravity, a large curriculum could be developed using space exploration as a unifying theme. Expansion of this concept could enhance objectives already initiated through the International Space University to include elementary and secondary school students. The ultimate goal would be to stimulate interest in space and space-related sciences in today's youth through creative educational marketing initiatives while at the same time drawing funds almost entirely from the private sector."*

## U.S. SPACE CAMP

A good example of an existing space education institution that would also benefit from the creation of educational programming developed on the ISS would be the US Space Camp. Wernher von Braun founded the U.S. SPACE CAMPS to expose young people to science and math, using the space program as the focal point of a course of study. The first camp was established at the U.S. Space & Rocket Center in Huntsville, Alabama in 1982. By 1999, the U.S. SPACE CAMPS will have graduated over 300,000 "trainees".

*"U.S. SPACE CAMP® is a five-day program jam-packed with astronaut training for young people. Activities include simulated Space Shuttle missions, IMAX® movies, training simulators (like the 1/6th Gravity Chair), rocket building and launches, scientific experiments, and lectures on the past, present, and future of space exploration.*

*We also offer programs for older students. SPACE ACADEMY® is for young people in grades 6-8* and ADVANCED SPACE ACADEMY® is for students in grades 9-12. Another popular program is Parent/Child SPACE CAMP -- a weekend of activities and missions where an adult/child pairs go through the same program together. We also have ADULT and TEACHER programs, plus CORPORATE SPACE ACADEMY, which uses shuttle missions and astronaut training to teach team building.*

*SPACE CAMP has been operating since 1982. We are the largest camp operation in the United States, having graduated almost 300,000 campers. SPACE CAMP programs in Alabama are operated by the U.S. Space & Rocket Center and the Alabama Space Science Exhibit Commission. California and Florida locations are owned and operated by the U.S. Space Camp Foundation, a non-profit organization. Alabama and Florida locations are accredited by the American Camping Association, and the new California locations are in the process of accreditation."*

## International Space University

The ISU offers graduate level courses in comprehensive, space applications, engineering, science, management, space policy, and law. ISU currently offers three programs: the Summer Session, the Master of Space Studies, and the Professional Development Program. Its course curricula also benefit greatly from educational programming generated on the ISS.

*"Many and varied practical applications, huge advances in understanding the cosmos, preparation for interplanetary exploration - these are some aspects of the progress accomplished in the utilization of space for peaceful purposes over the past forty years.*

*The world's space programs have become increasingly international and commercial in nature. New skills need to be developed and enhanced in order to manage the engineering, economic, political and organizational aspects of programs and space professionals of the future need a very broad base of knowledge.*

*At the International Space University, international experts train and educate professionals to take the lead in the international space arena.*

*Interdisciplinary diversity integrated into a coherent, structured whole in a truly international, multicultural environment. The originality of ISU's programs lies in this approach.*

*At ISU, all students study all space-related disciplines, vastly broadening their vision and enabling them to understand the complex interactions between disciplines. By approaching the utilization of space from a global perspective, ISU gives its graduates a powerful, competitive edge in the profession. They become capable of understanding and easily crossing the traditional barriers arising between individuals from different nations, with different cultural backgrounds. They break new ground in international cooperation on space programs."*

The JASON Project

*"What is the JASON Project? After discovering the wreck of the RMS Titanic, world-famous explorer Dr. Robert Ballard received thousands of letters from students around the world wanting to go with him on his next expedition. In order to bring the thrill of discovery to millions of students worldwide, Dr. Ballard founded the JASON Project, a year-round scientific expedition designed to excite and engage students in science and technology and to motivate and provide professional development for teachers. The JASON Project has been praised as the leader in distance learning programs, and continues to expand its reach by adding more "components" to the Project experience.*

*Through JASON XI, we will trace the path of ocean and space research and exploration. In the past, humans have been limited to very short visits to these extremes. The Aquarius Underwater Laboratory and the International Space Station allow humans to study oceans and space for longer time periods, and in new and exciting ways..."*

# ADVERTISING

**ADVERTISING CONTENTS:**



Description:

Advertising, as it relates to the ISS, represents a broad market category that includes the use of ISS in all areas related to sales and promotion. The international nature of the ISS and the presumed universal appeal of space will serve the advertising and marketing communities in an increasingly competitive global business environment. Advertisers will be able to use the ISS program indirectly through the licensing of ISS images and logo for advertising and merchandising or directly through on-orbit filming of commercial spots.

The domestic focus of this study dictates that we concentrate on the US advertising industry and its interest in the creation and broadcast of advertisements featuring the ISS. Historically, space programs such as Apollo and the space shuttle have been used widely in advertising and licensing tie-ins (e.g., Omega Watches). The use of Mir for on-orbit endorsements and filming of commercials has more recently proven the interest in space for a number of well-known international consumer products companies (e.g., Pepsi, Swatch).

## LICENSING, MERCHANDISING, AND ENDORSEMENTS

Description:

Licensing of images and logos of the International Space Station, merchandising of ISS-related products and, celebrity-style endorsements of products and services represent potentially significant sources of commercial revenue. There are some successful recent examples of this phenomenon (e.g., Mattel Hot Wheels Mars Rover), but the full extent of the ISS-related potential is yet to be realized.

Merchandising of the t-shirt and coffee mug variety has been a staple of the gift-shop economies surrounding NASA's space flight centers for many years. The visitor centers at Kennedy Space Center in Florida and Johnson Space Center in Texas represent particularly large merchandising operations, with their respective space center tours and gift shops. While merchandising does generate large revenues for the local economies surrounding the NASA Space Centers, a variety of legislative and other constraints does not currently allow licensing fees to flow back to NASA.

Endorsement of products or services by active astronauts is currently prohibited by NASA. There are a variety of organizations that represent former astronauts as their "agents". They are able to arrange speaking engagements, presentations, autograph appearances, and product endorsements by a number of former astronauts.

NASA Imagery Usage Policy:

*"1) NASA does not endorse or sponsor any commercial product, service, or activity.*

2) *The use of the NASA name, initials, any NASA emblems (including the NASA Insignia, the NASA Logo and the NASA Seal) which would express or imply such endorsement or sponsorship is strictly prohibited.*

3) *Use of the NASA name or initials as an identifying symbol by organizations other than NASA (such as on foods, packaging, containers, signs, or any promotional material) is prohibited. The only exceptions are noted immediately below.*

4) *NASA does permit the use of the NASA Logo and Insignia on novelty and souvenir-type items. However, such items may be sold and manufactured only after a proposal has been submitted to and approved by a representative from the Public Services Division (202/358-1750) in accordance with 14 CFR (Code of Federal Regulations) Part 1221. NASA does not grant anyone exclusive rights to use any of the Agency identities.*

*5) No approval for use is authorized by NASA when the use can be construed as an endorsement by NASA of a product, service, or activity.*

*6) NASA emblems should be reproduced only from original reproduction proofs, transparencies, or computer files available from NASA Headquarters. Please be advised that approval must be granted by the Public Services Division before any reproduction materials can be obtained.*

*7) NASA should be acknowledged as the source of its material.*

*8) It is unlawful to falsely claim copyright or other rights in NASA material.*

*9) NASA shall in no way be liable for any costs, expenses, claims or demands arising out of use of NASA's cassettes and photographs by a recipient or a recipient's distributees.*

*10)NASA personnel are not authorized to sign indemnity or hold harmless statements, releases from copyright infringement, or documents granting exclusive use rights."*

Space Program and Entertainment Worlds to Collide at JPL, John G. Watson, Media Relations Office, Jet Propulsion Laboratory, September 19, 1998.

*"Toy manufacturers, entertainment industry executives and others interested in space program licensing opportunities are invited to attend the fourth annual Toys, Games and Multimedia Workshop "Playing Among the Planets 98," a one-day seminar at NASA's Jet Propulsion Laboratory.*

*With the success of last year's "Hot Wheels Sojourner Mars Rover Action Pack," Mattel's toy versions of the Mars Pathfinder rover and lander, interest in working with JPL to produce space-related toys and entertainment industry products has never been higher, say workshop planners."*

The Astronaut Connection

*"Astronauts have accomplished and experienced the things that represent dreams and imagination to the rest of us. They are universally trusted, respected and revered. People of all*

*ages and backgrounds have a fascination with this group of explorers. They are American heroes. Data Matrix is proud to bring you retired Astronauts who can make commercial appearances, give dynamic presentations, participate in promotional programs or be used for corporate and product endorsements. When a retired Astronaut appears they bring the excitement of space flight and can be available to:*

- *Give motivational speeches*
- *Deliver presentations to small or large groups*
- *Sign autographs and have pictures taken with attendees*
- *Be interviewed/promote their appearance in the local media*
- *Endorse companies and their products"*

## SPACE ADVERTISEMENT

Description:

Space advertisement consists of either commercial product placement or on-orbit filming. Product placement describes the placement of commercial products, advertisements or corporate logos in locations where they will be visible to cameras filming other on-orbit activities. On-orbit filming consists of filming actual advertisements in or around the orbiting facility, often with the crew taking part in the spot.

Mir Cosmonauts Pitch Pens on U.S. Television, Florida Today, February 8, 1998.

> *"Two Russian cosmonauts aboard the Mir space station, appearing live on the QVC shopping channel, set out to hawk the American-made $32.75 Fisher Space Pen, used on NASA space flights since 1967 because it can write in the absence of gravity. As they orbited 200 miles above the Earth, a technical problem kept Commander Anatoly Solovyov and flight engineer Pavel Vinogradov from being heard discussing the pen. So one of them simply used it to write "QVC" on a pad.*
>
> *But the featured attraction at the sale, anchored from the Catch a Rising Star nightclub in Manhattan, was the $25,000 Sokol KV-2 spacesuit.*
>
> *Russian space chief Yuri Koptev has said previously that Mir would be used regularly as an advertising prop.*
>
> *It doesn't make any difference for us what to advertise -- cars or foodstuff. The only condition is that advertising doesn't contradict legal and ethical norms,' Koptev said."*

Russian cosmonaut films milk ad on Mir space station, Florida Today, August 21, 1997.

> *"One small drop of milk; one giant leap for TV commercials.*
>
> *When he wasn't scrambling to fix his accident-prone space station, Mir cosmonaut Vasily Tsibliyev was busy making a television commercial for an Israeli brand of long-life milk."*
>
> *The commercial - broadcast Wednesday on Israel's Channel Two television - shows Tsibliyev swallowing a floating blob of Tnuva milk..."*

NASA Watch Website:

Draft Partner Program Directive concerning the proposed ISS external graphic markings:

*July 1999*

*T. W. Holloway, Manager*

*International Space Station Program*

*TO: Distribution*

***SUBJECT: International Space Station Program Guidelines for Graphic Markings on International Space Station Elements, Systems and Payloads***

***OFFICE OF PRIMARY RESPONSIBILITY: International Space Station Program Office***

***1.0 SCOPE AND OBJECTIVES***

*The participating parties to the International Space Station (ISS) Program have determined it to be in the best interests of the Program to ensure that all external graphic markings on ISS elements, systems and payloads shall be simple, professional, effective for identification, and, to the extent practical, standardized. Thus, notwithstanding the fact that each partner has its own internal standards and regulations, the guidelines set out below constitute a common set of agreed guidelines for external graphic markings on all ISS elements, systems and payloads.*

*These guidelines apply to graphic markings which are visible on the exterior of the ISS. These guidelines are applicable to ISS elements, systems, payloads and logistics resupply articles (for example, spares, maintenance items and consumables for ISS use). These guidelines do not cover graphic markings on the interior of the ISS or markings on ISS crew attire.*

*Each partner using its own space transportation system (expendable or reusable, launch vehicle or orbital transfer vehicle) to provide launch and or return transportation services for the ISS shall determine the graphic markings on their transportation systems.*

*For purposes of these guidelines, the provider of an element is the country/agency provider of record set out in the ISS Intergovernmental Agreement. For example, the United States/NASA is the provider of the Multipurpose -Pressurized Logistics Module, the FGB, the Centrifuge Accommodation Module and Nodes 2 and 3, notwithstanding the fact that these items were developed by other partners and participants. Similarly, the provider of a payload is the country/agency including the payload in its Partner Utilization Plan.*

***2.0 GUIDELINES FOR GRAPHIC MARKINGS ON ISS ELEMENTS, SYSTEMS AND PAYLOADS***

***A. Types of Markings***

*Each element, system and payload of the ISS may carry the providing partner's national colors, the name of the providing country, the name given the element, and the insignia of that partner's cooperating agency, and in the case of Japan, that partner's assisting agency -National Space Development Agency of Japan (NASDA).*

***B. Size and Location of Markings***

*The size and locations of the graphics area will be limited by applicable technical constraints as determined by the ISS Partner Program Managers and in no way interfere with the integrity of orbital debris shielding, or the environment for ISS operations, such as, thermal limits, Extravehicular Activity (EVA) hand rails, EVA and other markings etc.*

***C. Process for Approval of Markings***

*In order to facilitate timely compliance with these guidelines, each of the partners shall make known their plans and intentions for marking their elements, systems and payloads. The ISS Partner Program Managers, in the Space Station Control Board (SSCB) forum, with the support of the ISS Partners Public Affairs Office (PAO) Working Group, shall review each proposed marking to confirm its compliance with these guidelines. This review shall occur at least ten months prior to launch to assure that the markings may be finalized and affixed to the flight article no later than eight months prior to launch.*

***D. European Space Agency (ESA) Requirements***

*ESA shall be responsible for identifying the graphic markings for European elements, systems and payloads on behalf of its member states.*

***E. Participant Countries***

*In case of participant countries (e.g. Italy and Brazil), the partner country through which they participate shall coordinate and approve the graphic markings in conformance with these guidelines.*

***F. Receipt from Another Entity***

*In the event that a partner receives one of its elements, systems, payloads or other ISS component from another entity (for example, through a cooperative, barter or offset arrangement), the providing partner (as defined in section 1.0 above), shall determine, following consultation with the other entity, which country or agency markings shall appear on the hardware, in accordance with its internal procedures.*

***G. ISS Payloads***

*ISS payloads may display markings, in addition to those of their providers. No markings shall be approved if they interfere in any way with the mission.*

***3.0 MATERIALS STANDARDS FOR GRAPHIC MARKINGS***

*In order to avoid generation of orbital debris from unstable graphic markings on ISS systems, elements and payloads and visiting space transportation systems, the partners shall agree on materials standards for ISS graphic markings. These materials standards shall be documented in Space Station Program Document SSP 30233, "Space Station Requirements for Materials and Processes," under the control of the SSCB.*

***4.0 RESPONSIBILITY***

*A. The ISS Partner Program Managers, in the SSC13 forum, shall approve these guidelines and any additional guidelines required for ISS-related graphic markings. The ISS Partners Public Affairs PAO Working Group shall provide expert advice and recommendations. The ISS Partner Program Managers, with the support of the ISS PAO Working Group, shall review proposed markings to confirm compliance with the guidelines and shall be responsible for considering and granting waivers when appropriate.*

*B. Each partner shall be responsible for any internal coordination with its agency management, government or contractors.*

*C. Each partner shall be responsible for ensuring its elements, systems, payloads and space transportation systems comply with these guidelines.*

*D. All costs associated with the design, fabrication or application of markings shall be borne by the country/agency proposing the markings unless otherwise agreed as part of a cooperative arrangement.*

***5.0 REFERENCES***

*The following references are applicable to each individual agency, respectively.*

***A. NASA:***

*NASA Policy Directive 8610.6D: "Graphic Markings on Space Transportation Vehicles, U.S. Components of the International Space Station Component Systems, and Payloads."*

*NASA Policy Directive 87 10, "NASA Policy for Limiting Orbital Debris Generation."*

*Agency Graphics Standards as authorized by Headquarters Office of Public Affairs-*

*(1) NASA Insignia Graphics Standards, NP-212. (2) Graphic Standards Manual (Shuttle and Spaceflight Markings).*

*JSC-SE-R-006, "NASA JSC Requirements for Materials and Processes."*

*MSFC-STD-506, "Standard Materials and Processes Control.*

*B. RSA:*

*Government Standard*

*C. NASDA:*

*NASDA Internal Regulation Concerning "NASDA" Logo*

*BBD-000 157 Basic Design Manual of "NASDA" Logo*

*JAX-99058 Basic Design Manual of "KIBO" Logo*

*D. ESA:*

*ESA Corporate Identity Guide (May 1997)*

*ESA/ADMIN (98) 35, "ESA Corporate Visual Identity"*

*E. CSA:*

*Government of Canada Federal Identify Program*

*CSA Corporate Identity Policy*

***6.0 WAIVERS***

*On a case-by-case basis, the ISS Partner Program Managers may consider partner requests for waivers to these guidelines. If, after review and discussion of the proposed deviation, through the appropriate internal partner processes, the ISS Partner Program Managers determine the markings to be acceptable and/or in the best interest of the Program, they may grant a waiver. Markings already completed on the "Unity," "Zarya" and Space Station Remote Manipulator System and Mobile Remote Servicer Base System elements, are consistent with these guidelines and were exempt from this approval process.*

***VII. AMENDMENT***

*The SSCB shall consider amendments to these guidelines upon the written request of any partner or participant.*

*Approvals*
*Alain Dubeau Date*
*Program Manager*
*Canadian Space Station Program*
*Canadian Space Agency*
*Frank A. Longhurst Date*
*Head, Manned Spaceflight Department*
*European Space Agency*
*Hideo Takamatsu Date*
*Manager, Space Station Program*
*National Space Development Agency of Japan*
*Boris D. Ostroumov Date*
*Deputy Director General*
*Russian Space Agency*